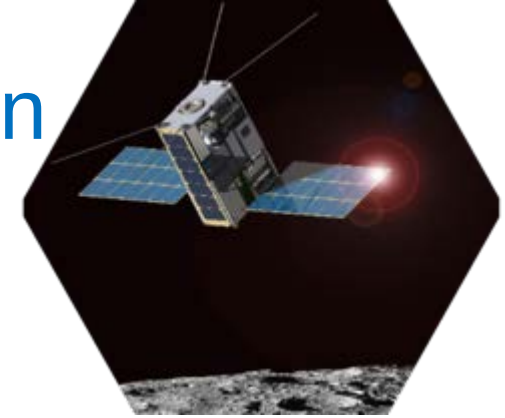
EXPLORE MOON to MARS

CLPS and Payloads Update

Dr. David Burns
Acting Deputy Associate Administrator for Exploration
Dr. Brad Bailey | ESSIO Program Scientist
Science Mission Directorate, NASA

October 2020

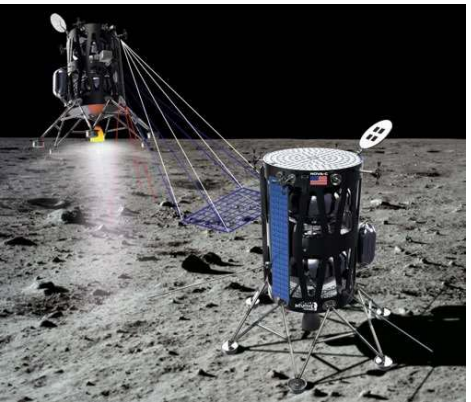
Exploration Science Strategy and Integration Office (ESSIO) formulates & executes an *integrated strategy* for exploration science



Implementation Strategy

- Develop lunar surface science instruments
- Use commercial companies to deliver payloads to the Moon
- Develop mobility systems to expand and enhance science investigations on the surface
- Leverage international partnerships for additional opportunities (e.g., instruments, rovers)
- Obtain new scientific data from lunar orbit using smallsats
- Use new human exploration systems, such as Gateway and human landing system, to enable science
- Lead the science mission planning for humans on the lunar surface

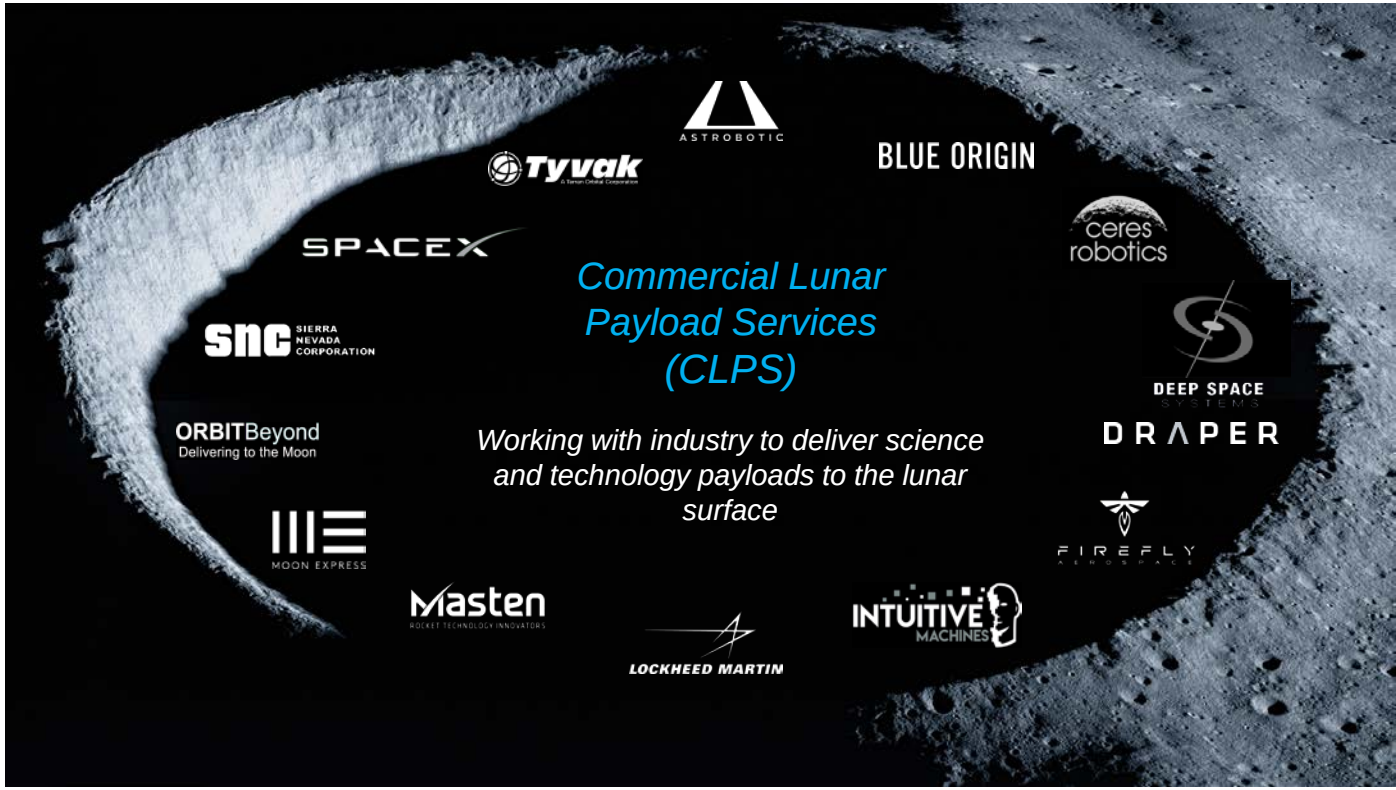
Lunar Discovery & Exploration Program (LDEP)



Commercial Lunar Payload Services (CLPS)

Goal: Utilize commercial end-to-end delivery services to enable access to the lunar surface

- Deliveries initiated using a Task Order
  - Any of the 14 companies on the catalog can respond to a task order
  - Expected Task Order cadence of 2 per year
- Task order lists what NASA wants delivered, and any constraints
  - E.g., landing site, specific needs of instruments
- First 4 lunar surface delivery task orders awarded with deliveries commencing in 2021
  - 2021: Non-polar delivery (Astrobotic and Intuitive Machines) – TO 2A & 2B
  - 2022: Polar delivery (Masten) – TO 19C
  - 2023: Volatiles Investigating Polar Exploration Rover (VIPER) to Moon's south polar region (Astrobotic) – TO 20A

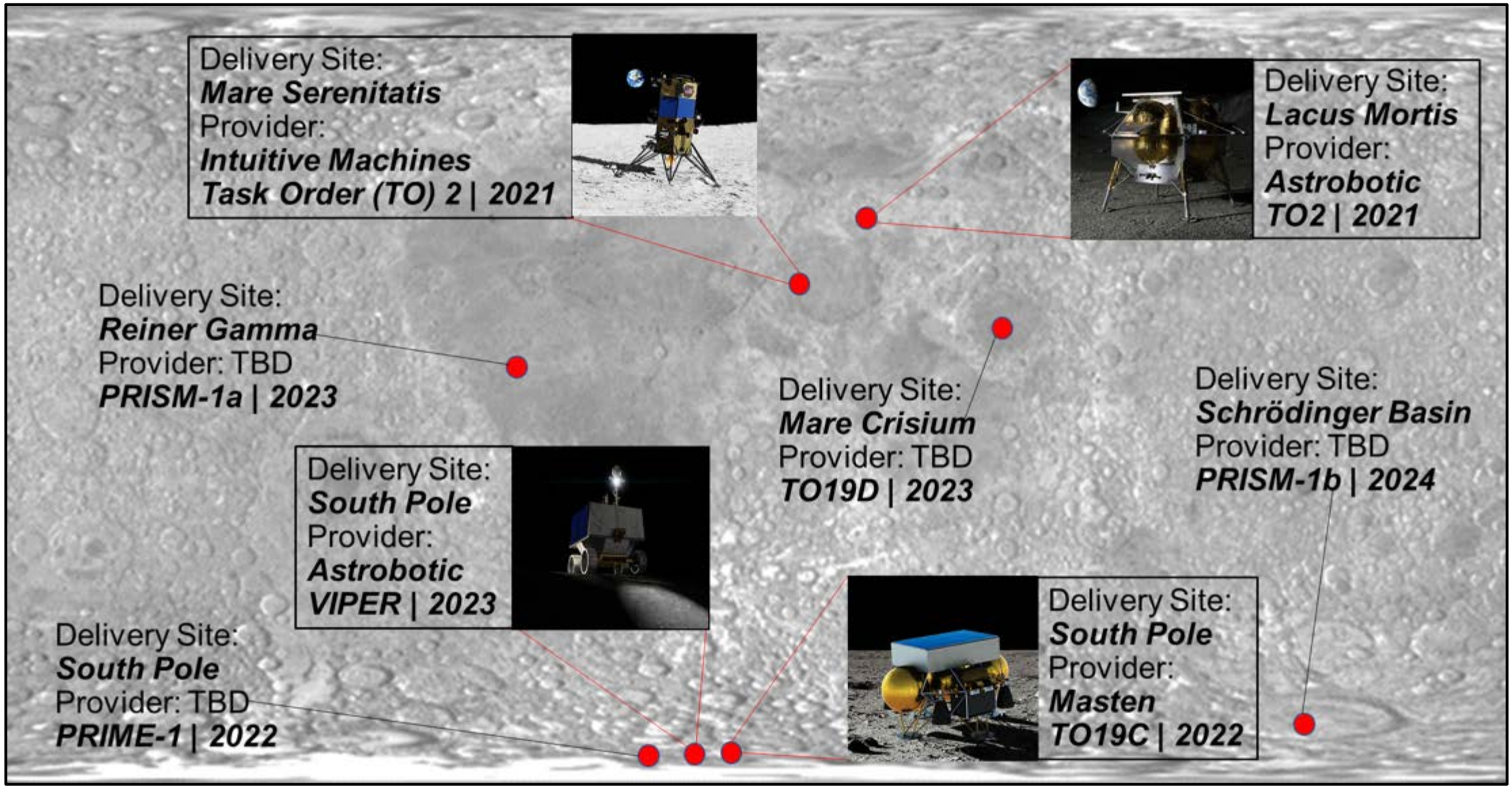


CLPS Deliveries & Future Payloads

Payloads and Research Investigations for the Surface of the Moon (PRISM)

- PRISM RFI: 238 Responses from the community received
  - Catalog of potential instruments
- PRISM stage-2 solicitations will state location for each delivery, allowing PIs to propose science optimized for those locations
  - High-value ‘location agnostic’ instruments will be called for in PRISM-2
  - International contributions to PRISM investigations may be included at up to 30% the total cost of the investigation
  - PRISM instruments will feed the manifests for Task Orders for deliveries from late 2023 onwards
  - Can be expanded to include orbital payloads
  - July 20 community announcement provided a heads-up on the first Stage 2 call and also identified the destinations for the 2 deliveries
    - ❖ Reiner Gamma magnetic anomaly (lunar swirl)
    - ❖ Schrödinger farside basin impact melt
  - Payloads from other NASA mission directorates are also incorporated into Task Orders

CLPS Deliveries 2021-2024



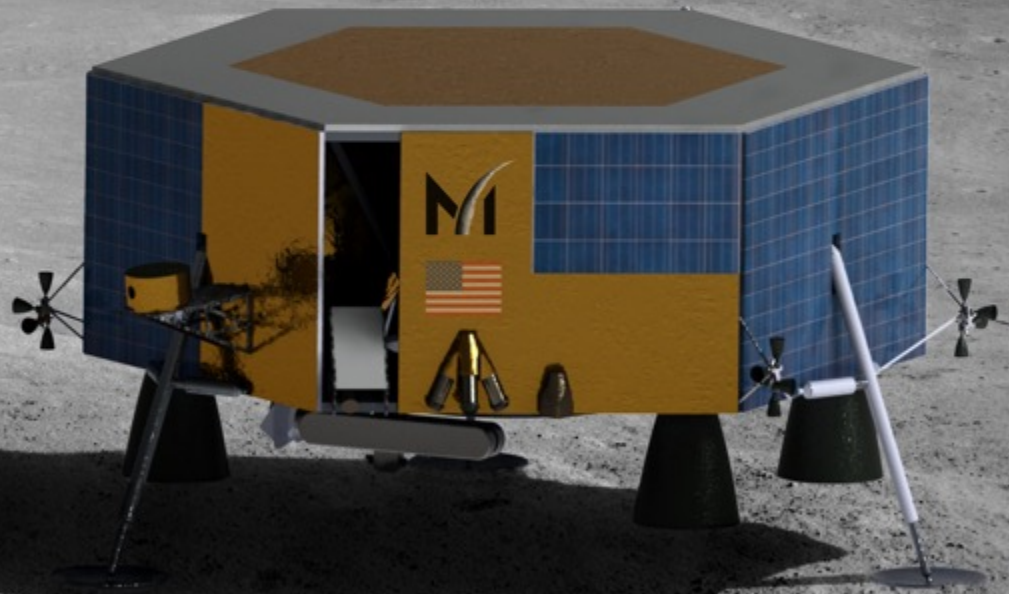
TO2 – INTUITIVE MACHINES
October 2021 launch

- Interface Control Documents virtually done; working through details of Payload Integration Plans
- Environmental test plan baselined

TO2 – ASTROBOTIC TECHNOLOGY
July 2021 Launch

- New facility for Astrobotic is complete
- Most recent milestone in Sept '20

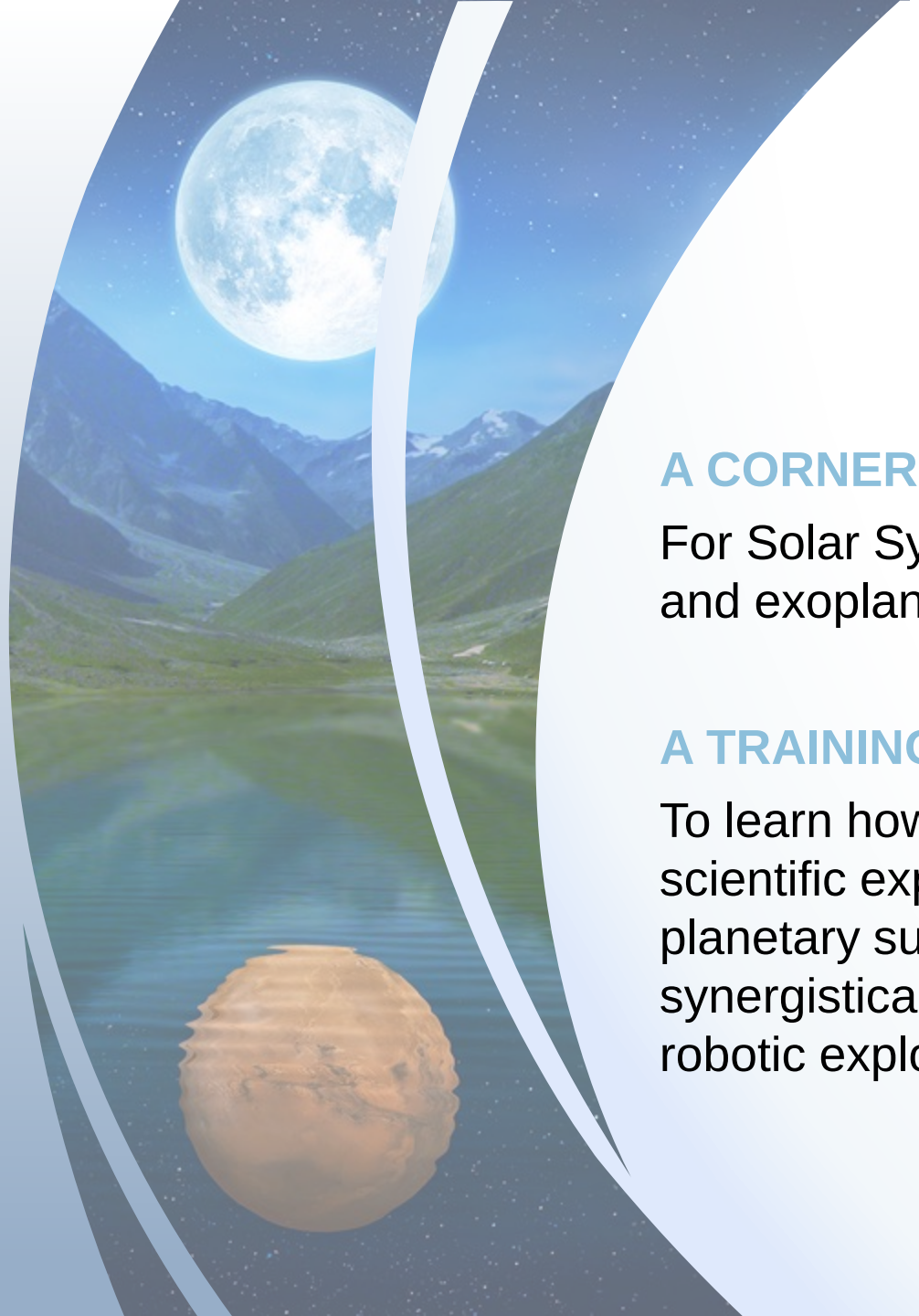
TO19C – MASTEN
December 2022 Launch



- Held payload kick off meeting; regular interactions going well
- Selected their launch vehicle provider
- Payload requirements draft complete and sent to the instrument Principal Investigators

TO20A – Astrobotic Technology 2023 Launch

- Strong start to understanding interfaces and concept of operations
- Astrobotic list of VIPER deliverables communicated and accepted
- Established 3x per week meeting cadence between Payload Integration Manager, Astrobotic, and VIPER team



The Moon Enables Scientific Exploration

A CORNERSTONE

For Solar System science and exoplanet studies

A NATURAL LABORATORY

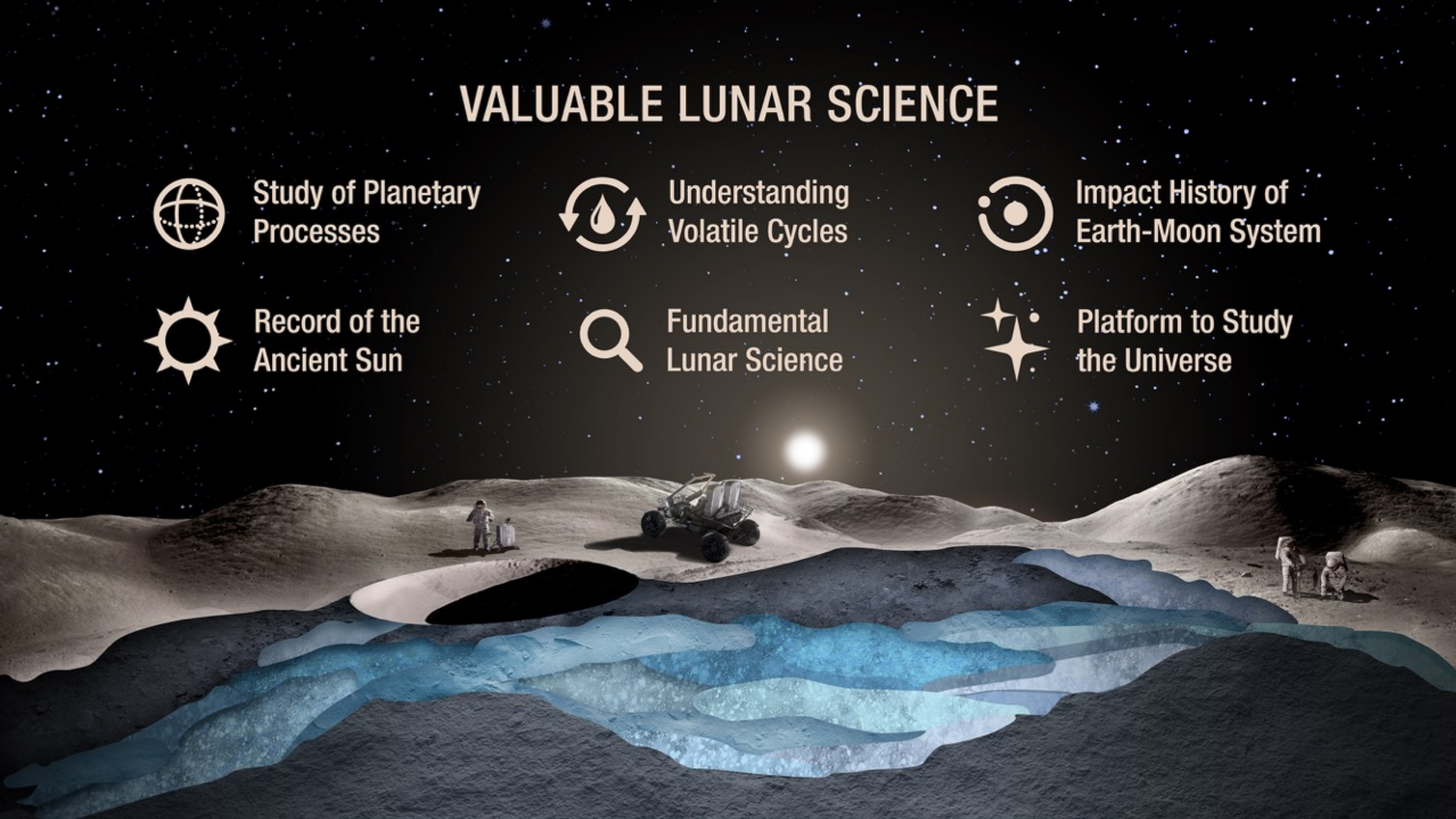
To study planetary processes and evolution

A TRAINING GROUND

To learn how to conduct scientific exploration from a planetary surface, working synergistically with crew and robotic explorers

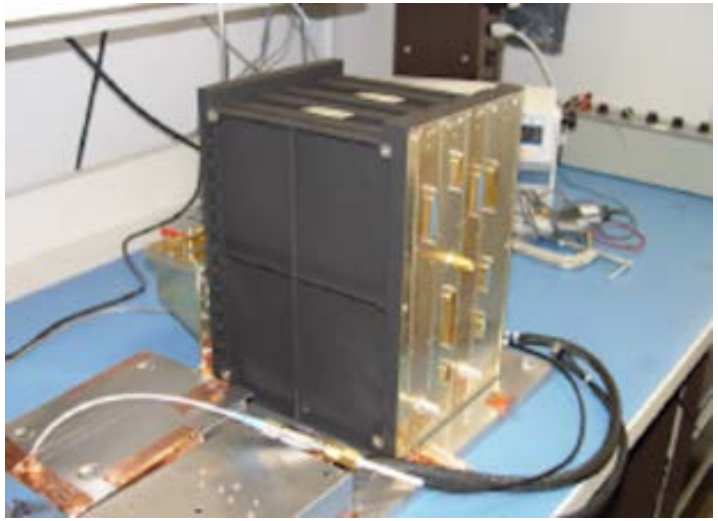
AN OPPORTUNITY

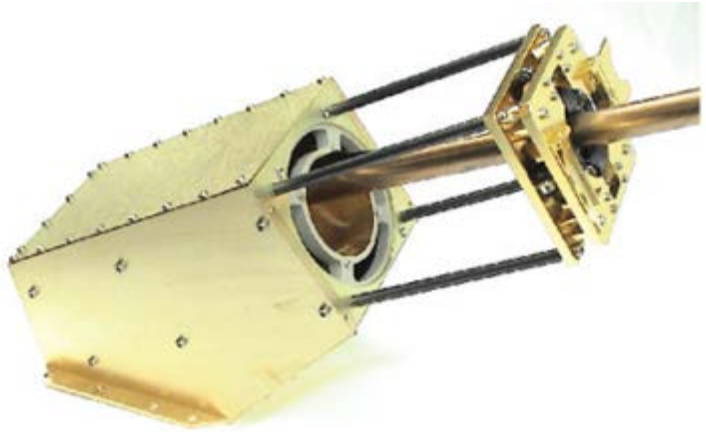
To use infrastructure and resources associated with human exploration to leverage support for autonomous scientific investigations


VALUABLE LUNAR SCIENCE
Study of Planetary Processes
Understanding Volatile Cycles
Impact History of Earth-Moon System
Record of the Ancient Sun
Fundamental Lunar Science
Platform to Study the Universe

NPLP-0034

ROLSES: Low-frequency Radio Observations from the Near Side Lunar Surface



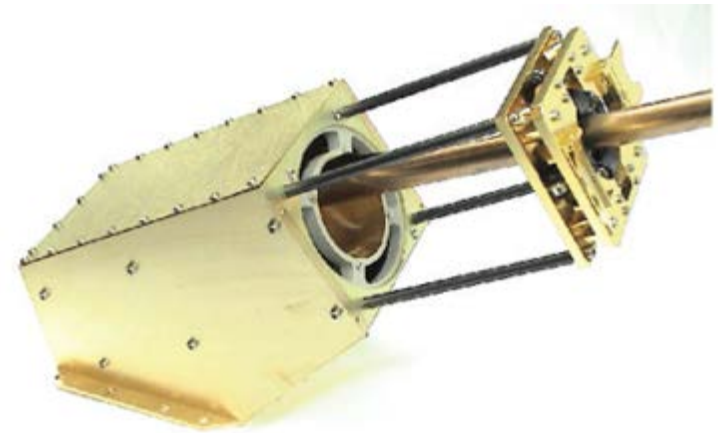


- Lead Development Organization: NASA GSFC
- Payload PI: Robert MacDowall
- Lander Partner: Intuitive Machines
- Payload Delivery Date: Q1 2021
- Payload Mass: 14.6 kg
- Payload Dimensions: 18 x 15 x 15 cm
- Payload Description:
  - *The ROLSES payload is a low-frequency radio astronomy receiver system that is based on the STEREO spacecraft WAVES instrument.*
  - *The four deployable, monopole, stacer antennas are based on those used for STEREO WAVES and will be combined as dipoles to improve measurement sensitivity.*
  - *The payload will employ a low-frequency radio receiver system to determine the photoelectron sheath density and scale height.*

ROLSES Low-Frequency Radio Receiver (top)
ROLSES Stacer Antenna (bottom)

LSITP-0027

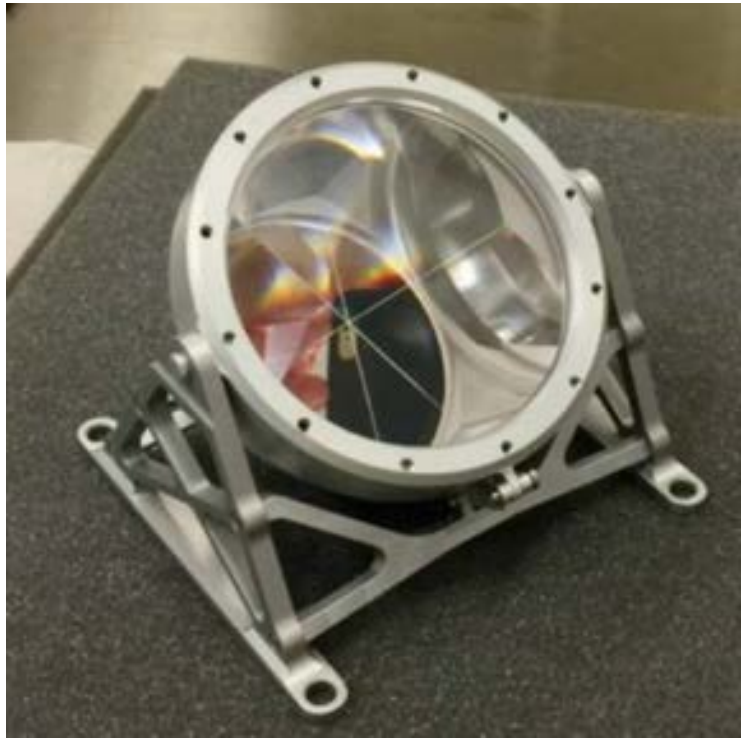
LuSEE: The Lunar Surface Electromagnetics Experiment



- Lead Development Organization: University of California, Berkeley
- Payload PI: Stuart Bale
- Payload Delivery Date: Q2 2024
- Payload Mass: 14.0 kg
- Payload Dimensions: 12 x 14 x 25 cm
- Payload Description:
  - *LuSEE is a flight-spare payload from the FIELDS experiment on the recently-launched Parker Solar Probe spacecraft*
  - *LuSEE will measure the electromagnetic and electrostatic environment of the Lunar surface, including surface electric potentials, magnetic fields, and electrostatic signatures of dust*
  - *The LuSEE suite will also measure radio emissions from the Sun, Earth, and outer planets*
  - *The surface potential measurements will address the formation, and structure, of the Lunar photoelectron sheath and the interaction of the Lunar surface with plasma from the solar wind and terrestrial magnetotail*

LSITP-0044

NGLR: Next Generation Lunar Retroreflectors

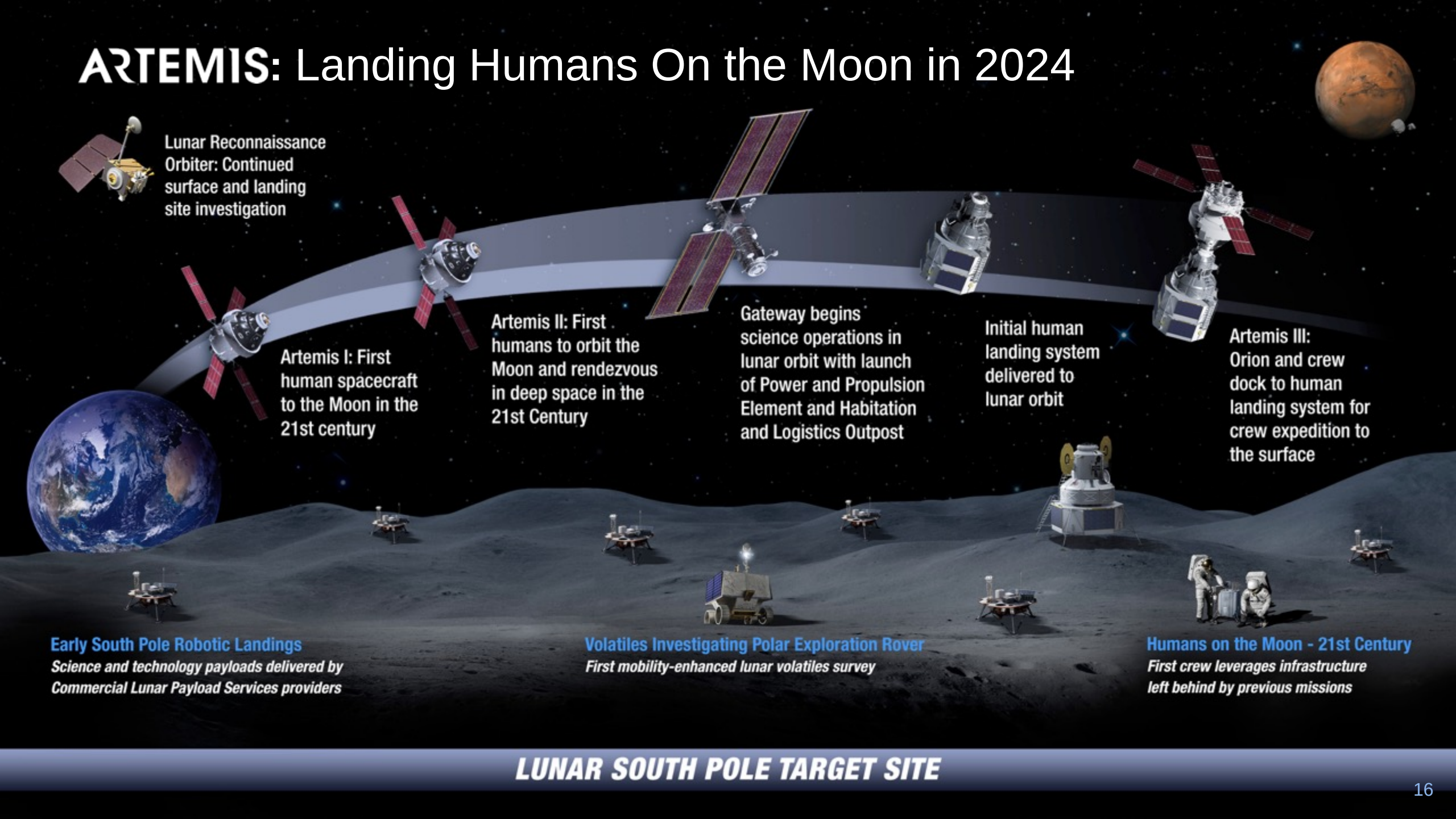


- Lead Development Organization: University of Maryland
- Payload PI: Douglas Currie
- Payload Delivery Date: Q2 2023, 19D delivery to Mare Crisium
- Payload Mass: 1.2 kg
- Payload Dimensions: 13 x 13 x 15 cm
- Payload Description:
  - The NGLR will improve the accuracy for a single range measurement, as compared to the Apollo retroreflector arrays, by a factor of 100.
  - The deployment of a NGLR will extend the scientific and technical heritage of the Lunar Laser Ranging (LLR) Program.
  - The increased accuracy will result in improved science by ranging to the deployed NGLR. Specific improvements will be realized for:
    - Lunar core oblateness, elastic tides, Lunar tidal dissipation, Core/Mantle boundary dissipation, Free physical librations, Lunar cartography, and gravitomagnetism.

CLPS Manifest Selection

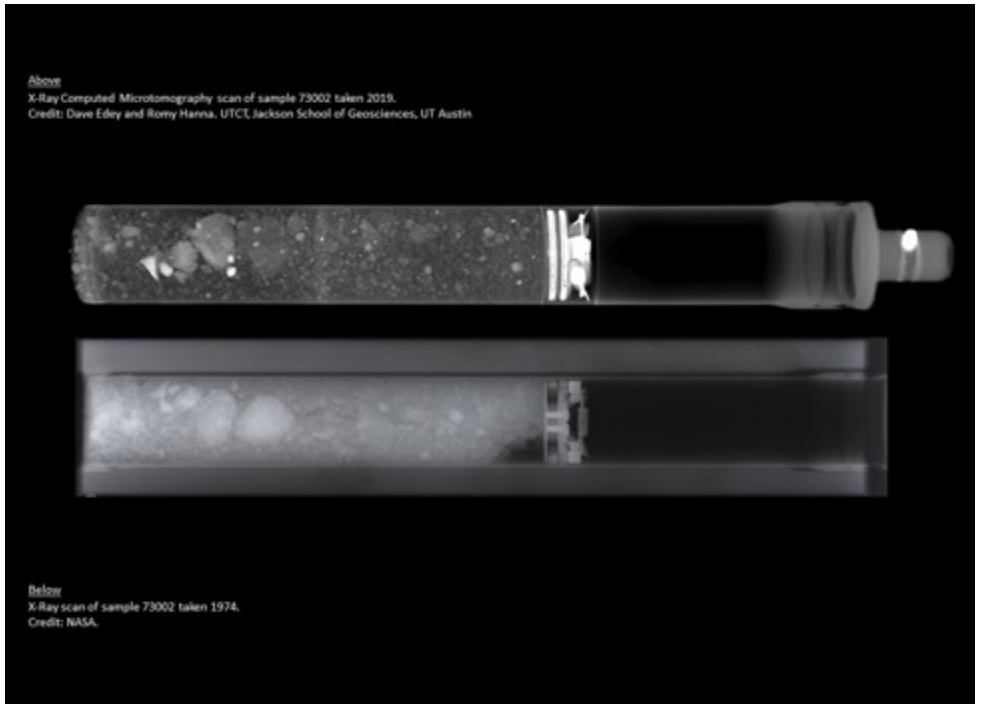
- CLPS delivery manifests are selected through the CLPS Manifest Selection Board (CMSB)
  - The CMSB includes representatives from SMD, HEOMD, STMD, OIIR, and the CLPS Project Office
- Selected payloads are chosen from among solicitations to the community, directed work, and international contributions; payloads are based on priorities and available budget from each respective Mission Directorate
  - Each Mission Directorate has a dedicated allocation on every CLPS delivery
- SMD will primarily use the Payloads and Research Investigations for the Surface of the Moon (PRISM) solicitation, planned approximately annually.
  - PRISM solicitations are open to HEOMD/STMD and will state the location for each delivery, allowing PIs to propose science optimized for those locations
    - High-value ‘location agnostic’ instruments and network science will be in future calls
    - International contributions to PRISM investigations may be included at up to 30% the total cost of the investigation
  - PRISM will also call out previously identified payloads for a particular delivery in order to solicit for complementary investigations and reduce redundancy

ARTEMIS: Landing Humans On the Moon in 2024



Backup

ANGSA:
Apollo Next Generation Sample Analysis



- Nine teams selected to analyze untouched Apollo samples
- Samples returned by Apollos 15 & 17 have been stored in pristine condition
- Will use techniques not available in the 1970s

NASA MISSIONS TO THE MOON

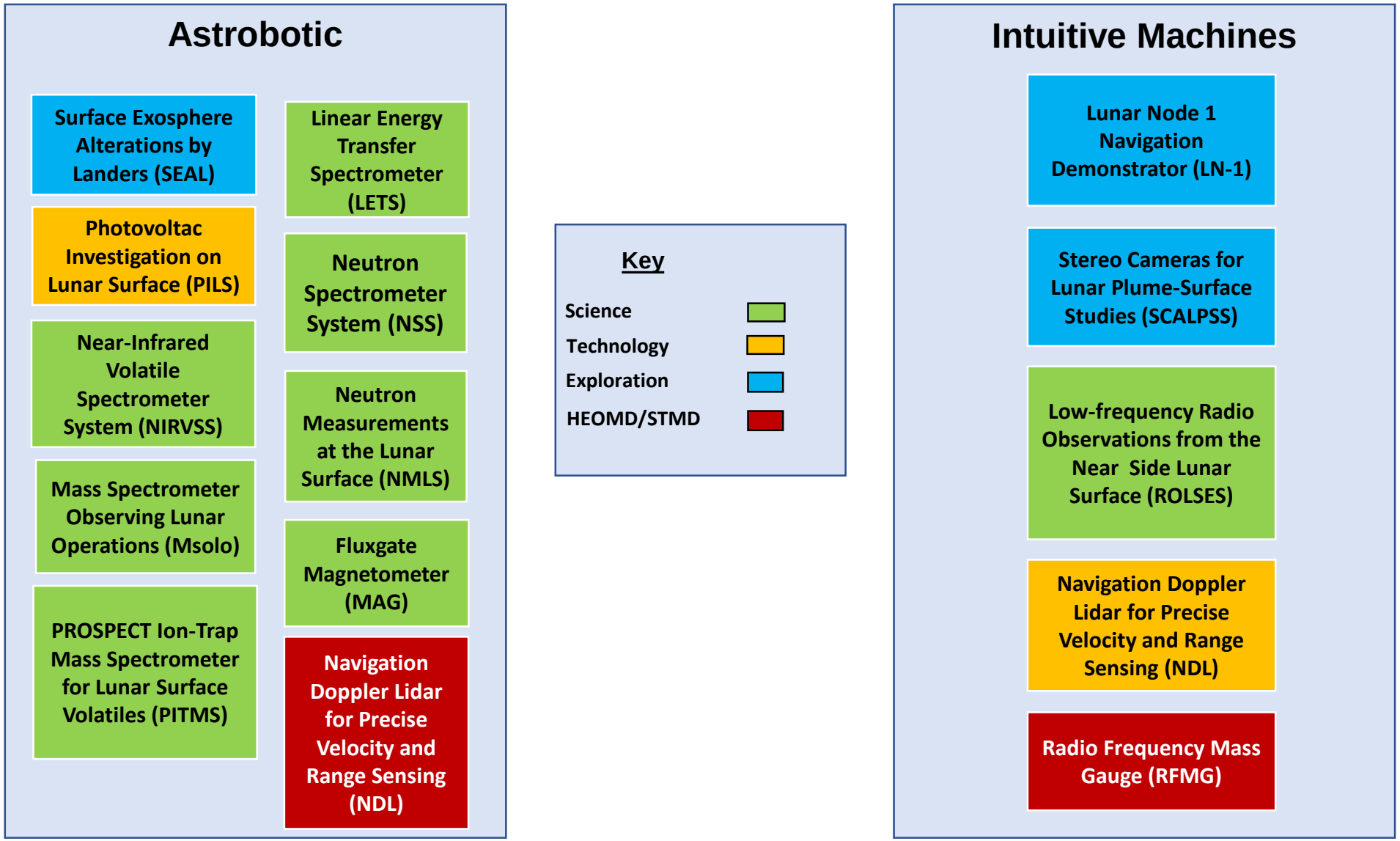
SCIENCE

HUMAN EXPLORATION AND OPERATIONS

SPACE TECHNOLOGY

Payloads largely selected from NASA Provided Lunar Payloads (NPLP)

2021 CLPS Delivery Manifests



Payloads largely selected from Lunar Surface Instrument and Technology Payloads (LSITP)

2022 CLPS Delivery Manifests

Polar

Masten Space Systems – South Pole

- Sample Acquisition, Morphology Filtering & Probing of Regolith (SAMPLR)
- Camera System for lunar science on commercial vehicles (Heimdall)
- Near-Infrared Volatile Spectrometer System (NIRVSS)
- Linear Energy Transfer Spectrometer (LETS)
- Lunar Compact Infrared Imaging System (L-CIRiS)
- Moon Rover with Exploration Autonomy (Moon Ranger)
- Laser Retroreflector
- Mass Spectrometer Observing Lunar Operations (Msolo)
- Neutron Spectrometer System (NSS) – Deployed on Moon Ranger

Key

- Science
- Technology
- Exploration

Non-Polar

TBD – Crisium

- Lunar Environment Heliophysics X-Ray Imager (LEXI)
- Next Generation Lunar Retroreflectors (NGLR)
- Radiation Tolerant Computer System
- Sample Acquisition & Delivery System for Instruments & Sample Return (PlanetVac)
- Lunar Instrumentation for Subsurface Thermal Exploration with Rapidity (LISTER)
- Lunar Magnetotelluric Sounder (LMS)
- Regolith Adherence Characterization (RAC)

Advancing Beyond the Apollo Paradigm

- Field Geology with Significant Mobility
  - Study the origin and evolution of the Earth-Moon system on the lunar surface
    - The Moon has experienced geologic processes that shape all terrestrial planets: Impact Cratering, Volcanism, and Tectonism
    - Mobility on the surface is a key factor for enabling a range of scientific activities (e.g., accessing multiple geologic units, deploying experiments over a broad area)
    - Best achieved as a human/robotic partnership
- New Samples Are Critical
  - The geologic diversity of the Moon coupled with careful selection of samples for return to Earth will address a plethora of science questions
- Surface Instrumentation
  - Humans facilitate the placement of delicate surface instrumentation.
    - Radio experiment on the radio-quiet farside offers a unique opportunity for sensitive measurements of the early Universe
- Access to Regions with Cold Temperatures
  - Our knowledge of surface temperatures enable a volatile rich sample to be collected